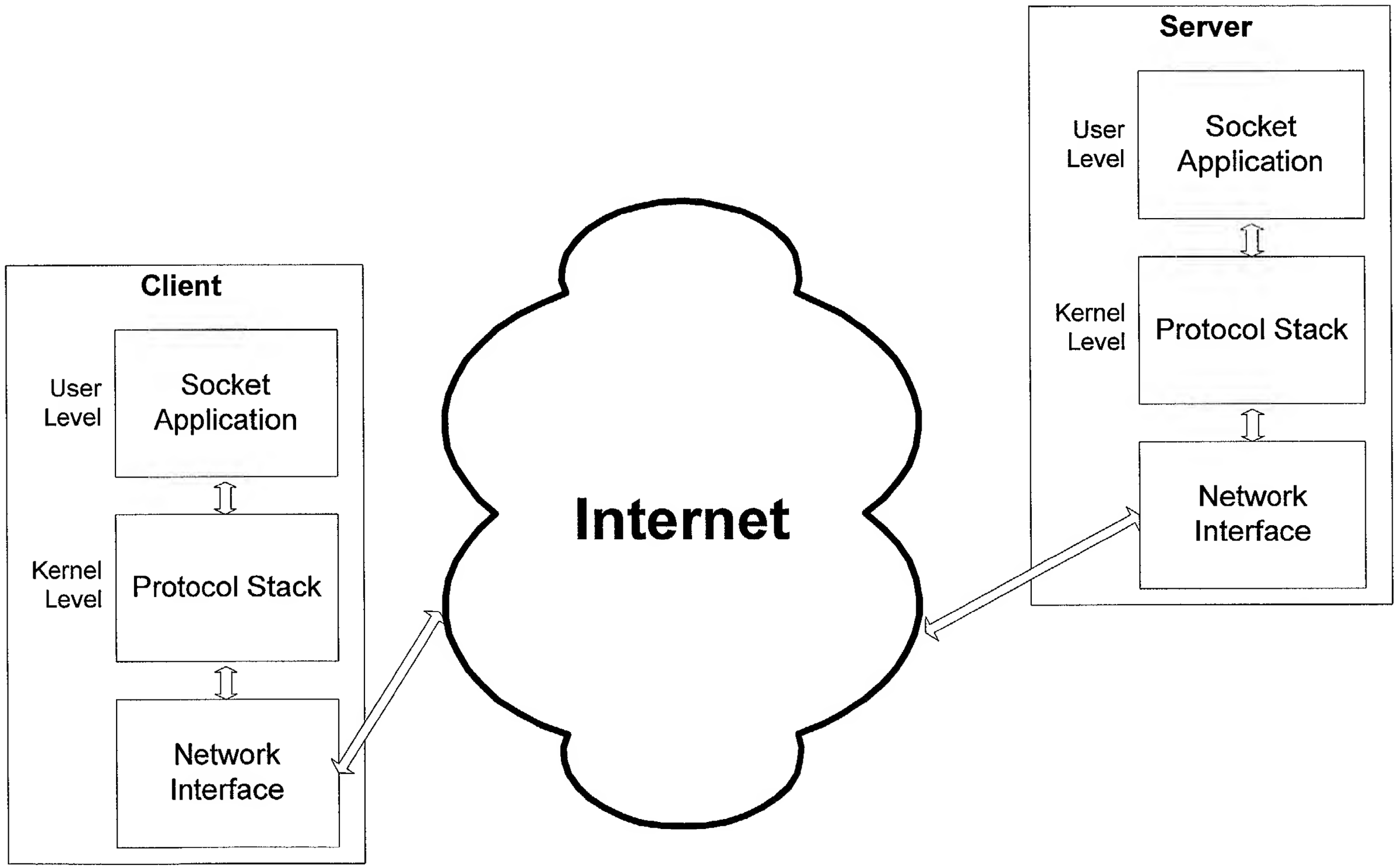

FIG. 1A
(Prior Art)

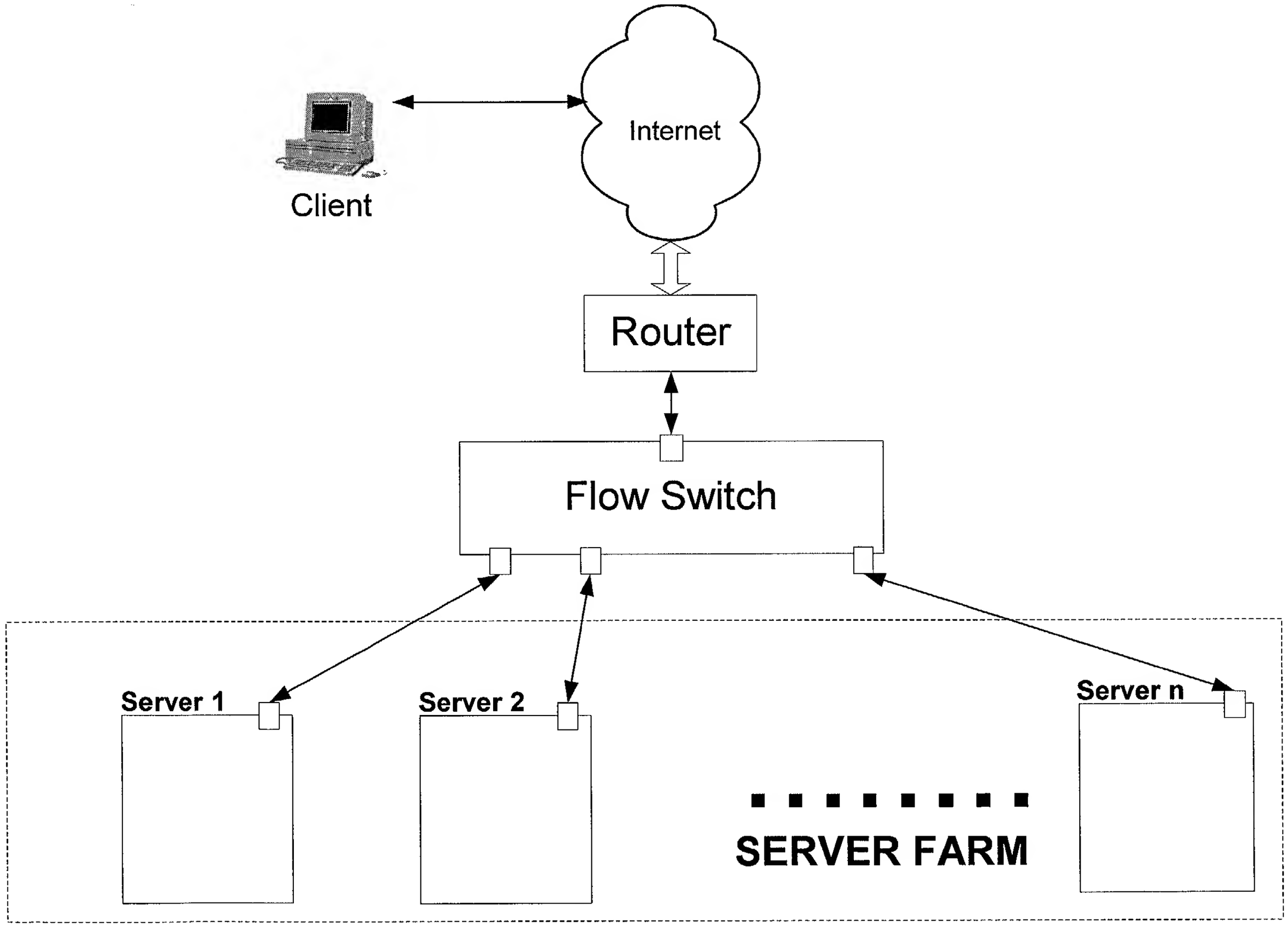

FIG. 1B
(Prior Art)

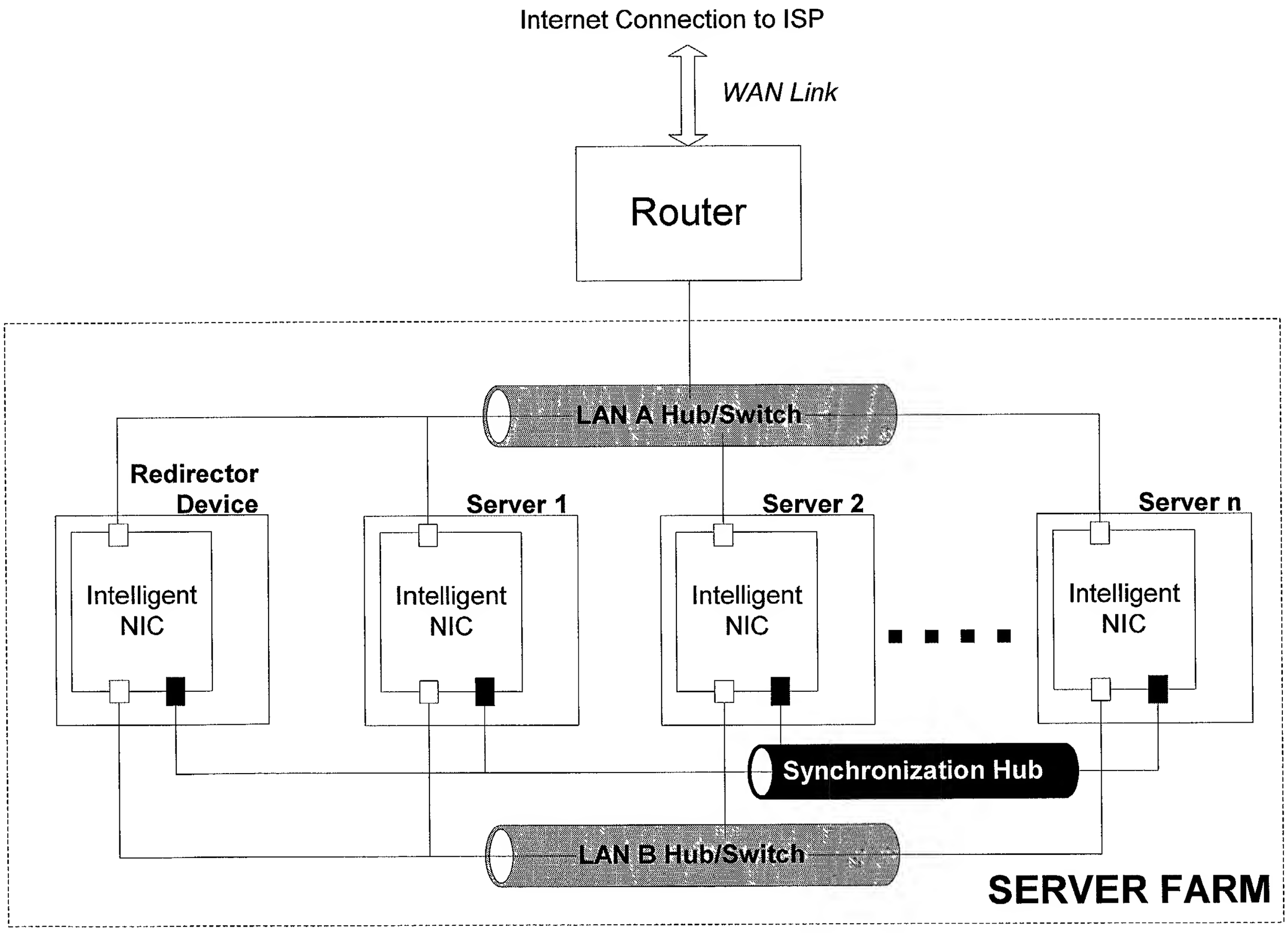
Internet Connection to ISP
WAN Link
Router
LAN A Hub/Switch
Redirector Device
Server 1
Server 2
Server n
Intelligent NIC
Intelligent NIC
Intelligent NIC
Intelligent NIC
Synchronization Hub
LAN B Hub/Switch
SERVER FARM

FIG. 2A

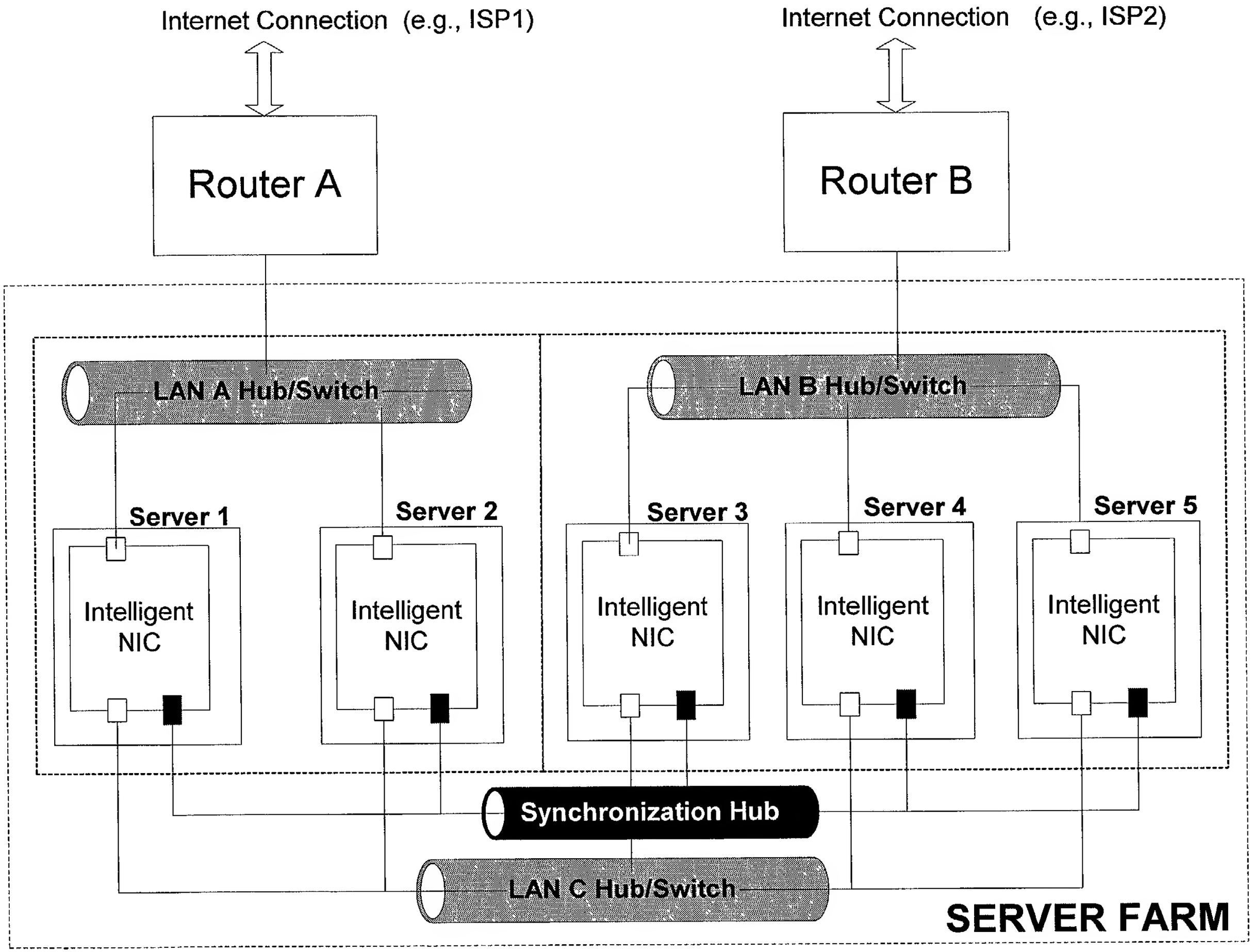
Internet Connection (e.g., ISP1)
Internet Connection (e.g., ISP2)
Router A
Router B
LAN A Hub/Switch
LAN B Hub/Switch
Server 1
Server 2
Server 3
Server 4
Server 5
Intelligent NIC
Intelligent NIC
Intelligent NIC
Intelligent NIC
Intelligent NIC
Synchronization Hub
LAN C Hub/Switch
SERVER FARM

FIG. 2B

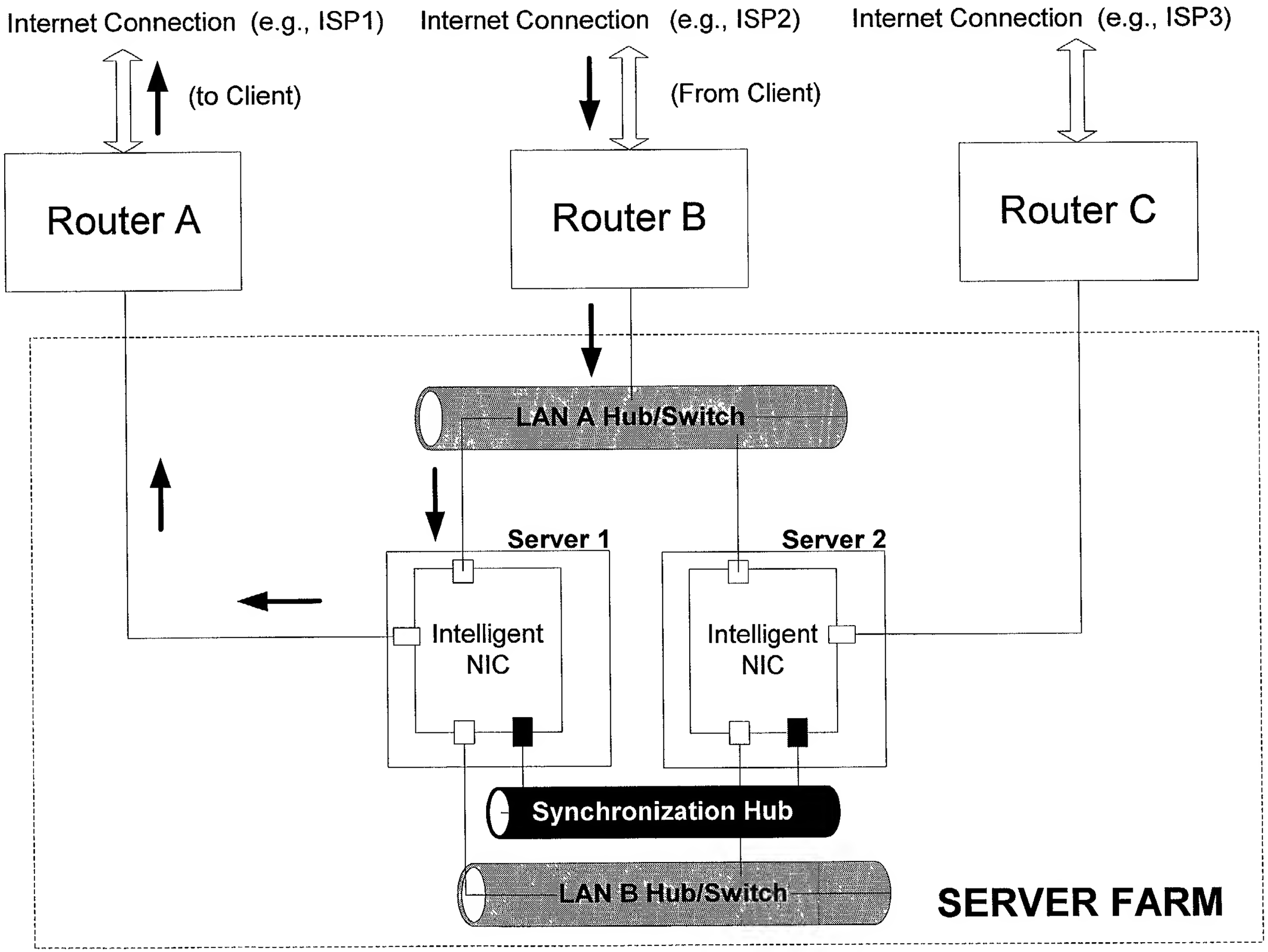
Internet Connection (e.g., ISP1)
Internet Connection (e.g., ISP2)
Internet Connection (e.g., ISP3)
(to Client)
(From Client)
Router A
Router B
Router C
LAN A Hub/Switch
Server 1
Server 2
Intelligent NIC
Intelligent NIC
Synchronization Hub
LAN B Hub/Switch
SERVER FARM

FIG. 2C

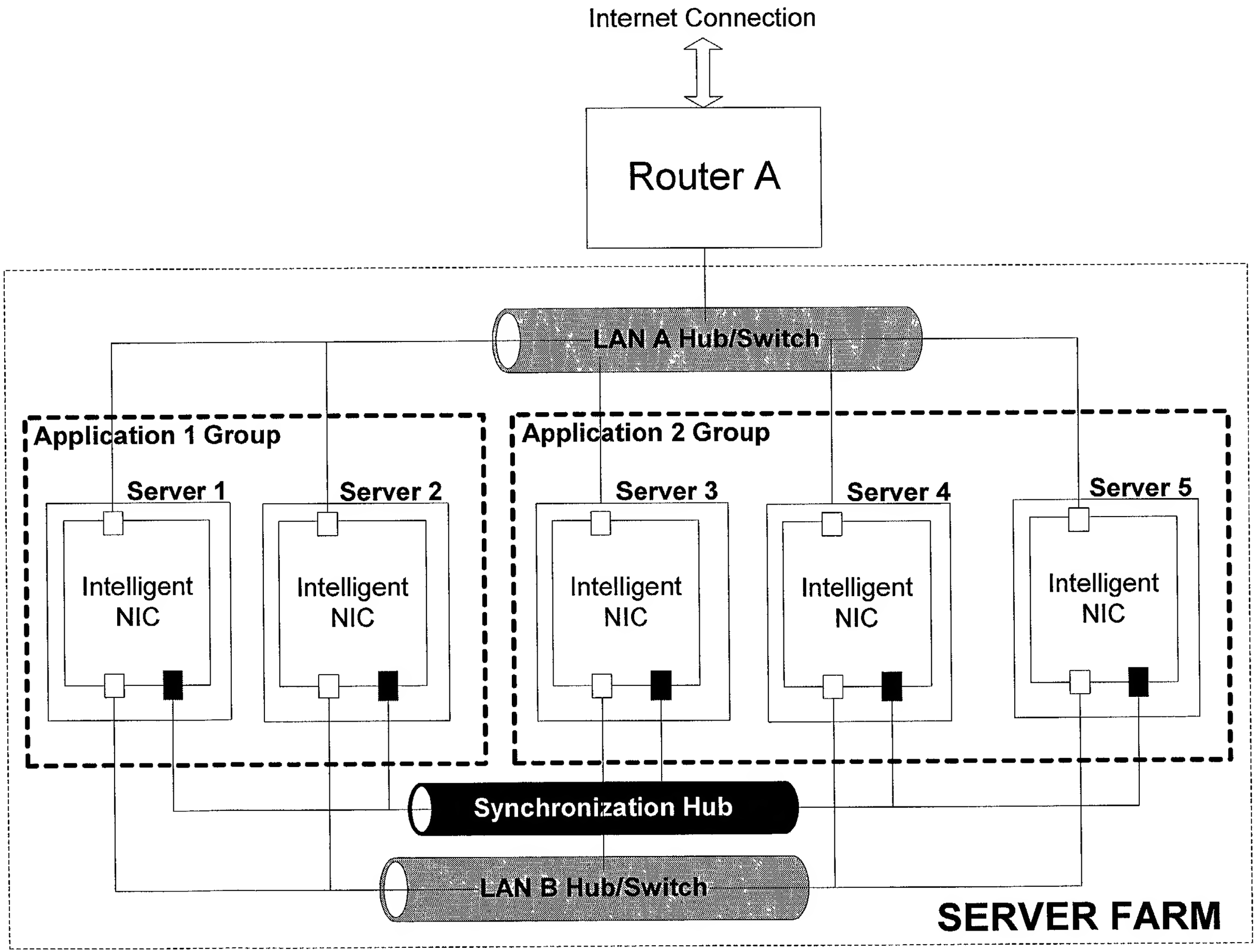
Internet Connection
Router A
LAN A Hub/Switch
Application 1 Group
Application 2 Group
Server 1
Server 2
Server 3
Server 4
Server 5
Intelligent NIC
Intelligent NIC
Intelligent NIC
Intelligent NIC
Intelligent NIC
Synchronization Hub
LAN B Hub/Switch
SERVER FARM

FIG. 2D

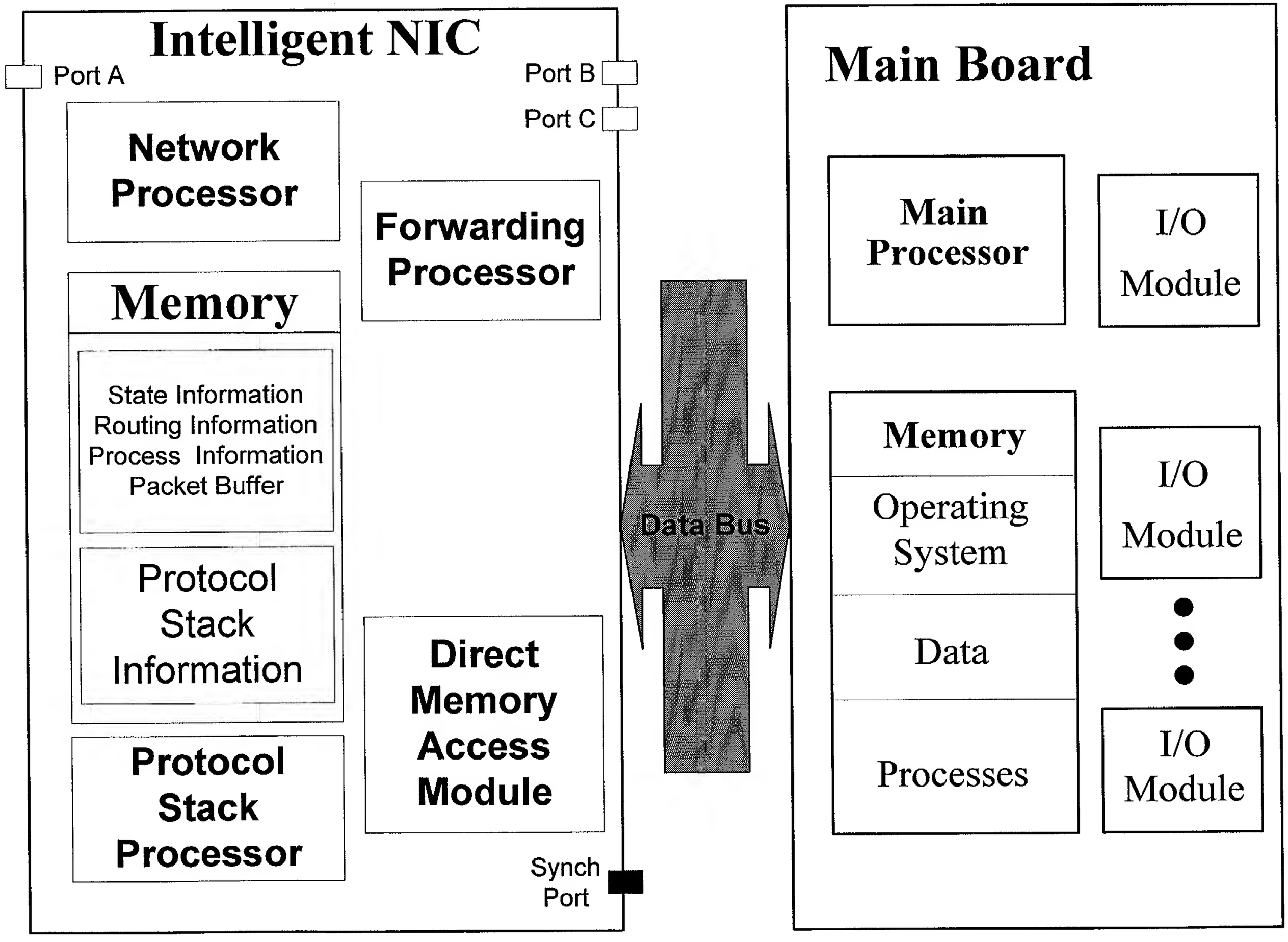
Intelligent NIC
Port A
Port B
Port C
Network Processor
Forwarding Processor
Memory
State Information
Routing Information
Process Information
Packet Buffer
Protocol Stack Information
Protocol Stack Processor
Direct Memory Access Module
Synch Port
Data Bus
Main Board
Main Processor
I/O Module
Memory
Operating System
Data
Processes
I/O Module
I/O Module

FIG. 3

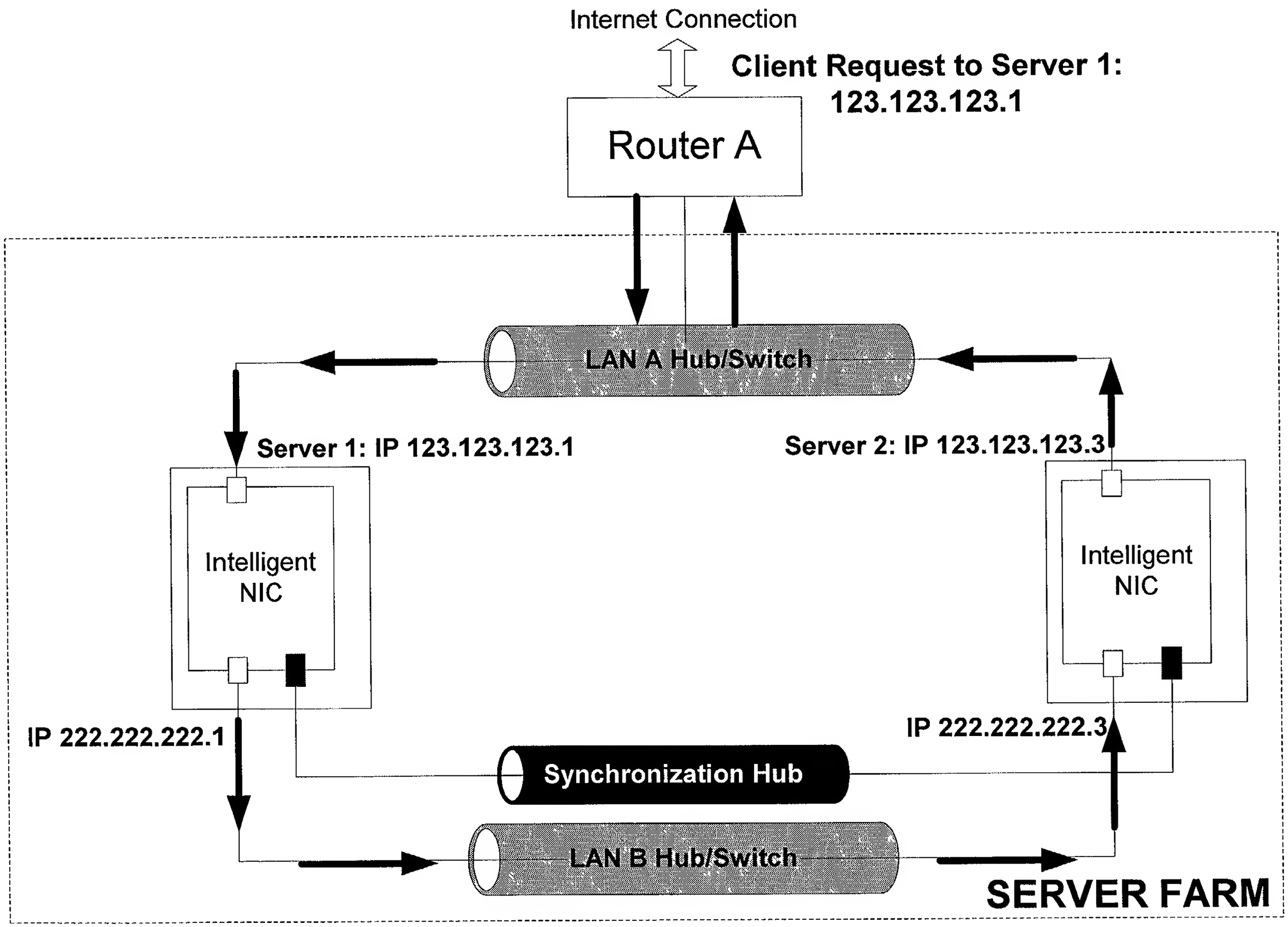
Internet Connection
Client Request to Server 1:
123.123.123.1
Router A
LAN A Hub/Switch
Server 1: IP 123.123.123.1
Server 2: IP 123.123.123.3
Intelligent
NIC
Intelligent
NIC
IP 222.222.222.1
IP 222.222.222.3
Synchronization Hub
LAN B Hub/Switch
SERVER FARM

FIG. 4A

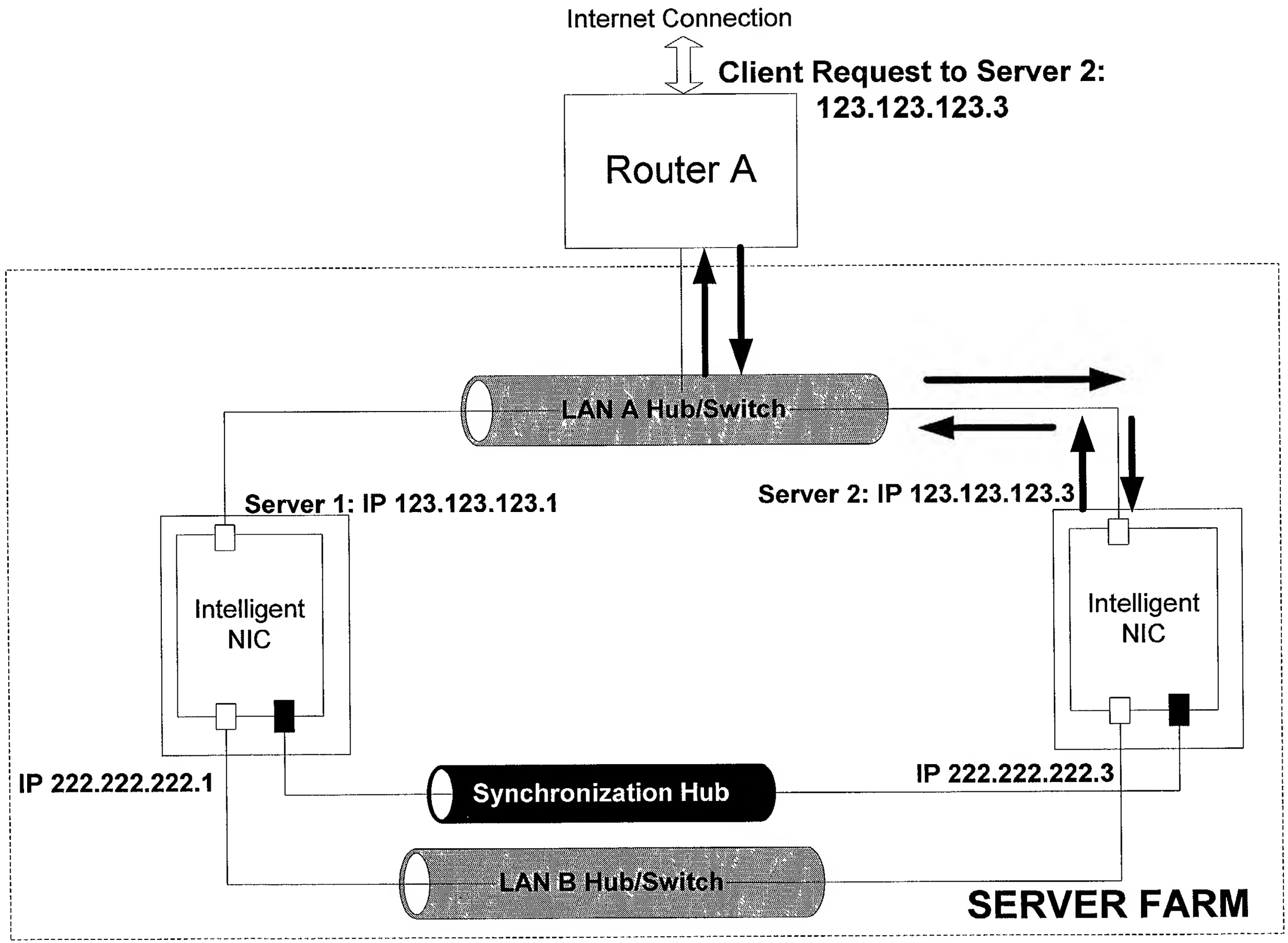
Internet Connection
Client Request to Server 2:
123.123.123.3
Router A
LAN A Hub/Switch
Server 1: IP 123.123.123.1
Server 2: IP 123.123.123.3
Intelligent
NIC
Intelligent
NIC
IP 222.222.222.1
Synchronization Hub
IP 222.222.222.3
LAN B Hub/Switch
SERVER FARM

FIG. 4B

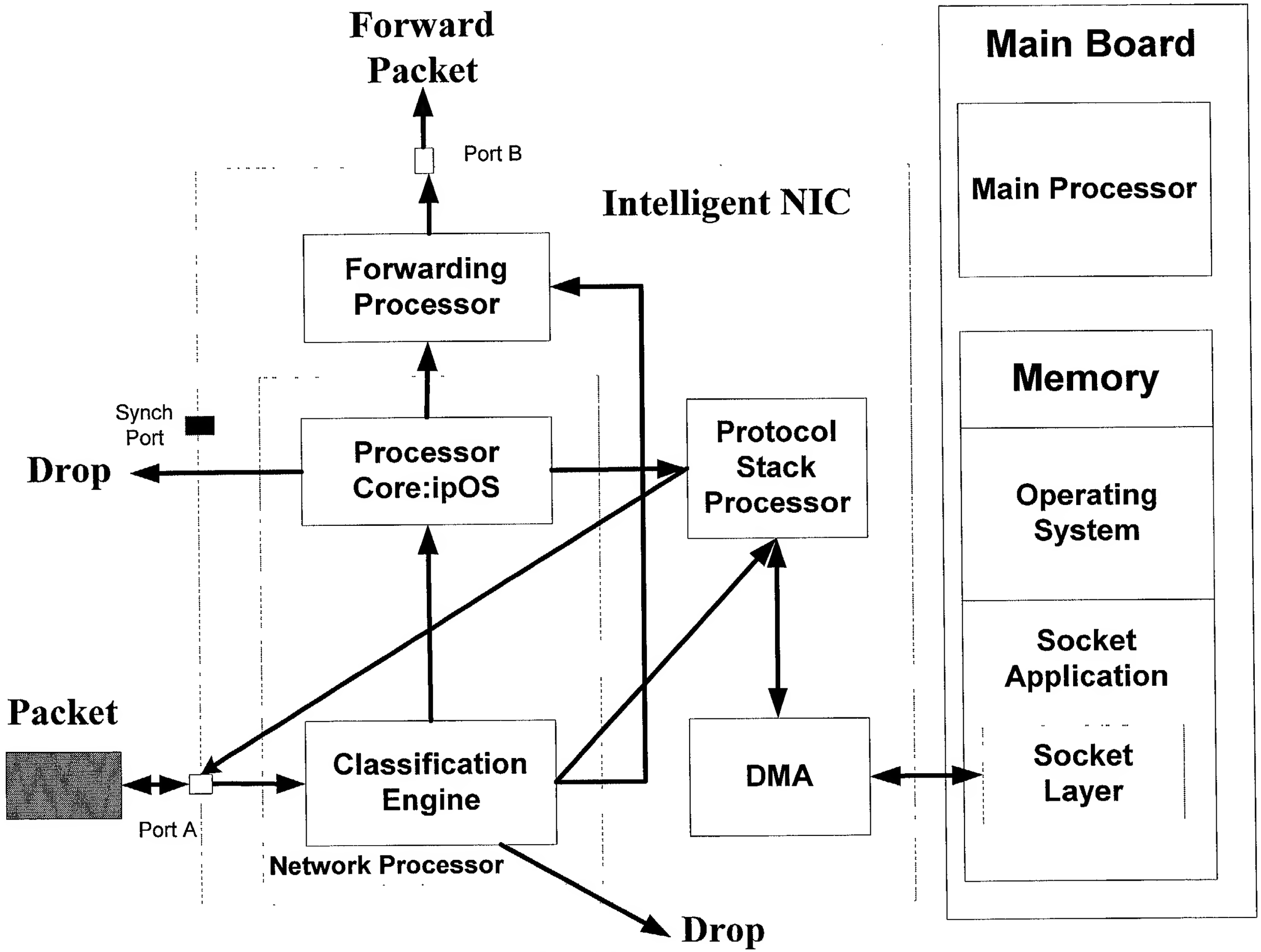
Forward Packet
Port B
Intelligent NIC
Forwarding Processor
Synch Port
Drop
Processor Core:ipOS
Protocol Stack Processor
Packet
Classification Engine
DMA
Port A
Network Processor
Drop
Main Board
Main Processor
Memory
Operating System
Socket Application
Socket Layer

FIG. 5A

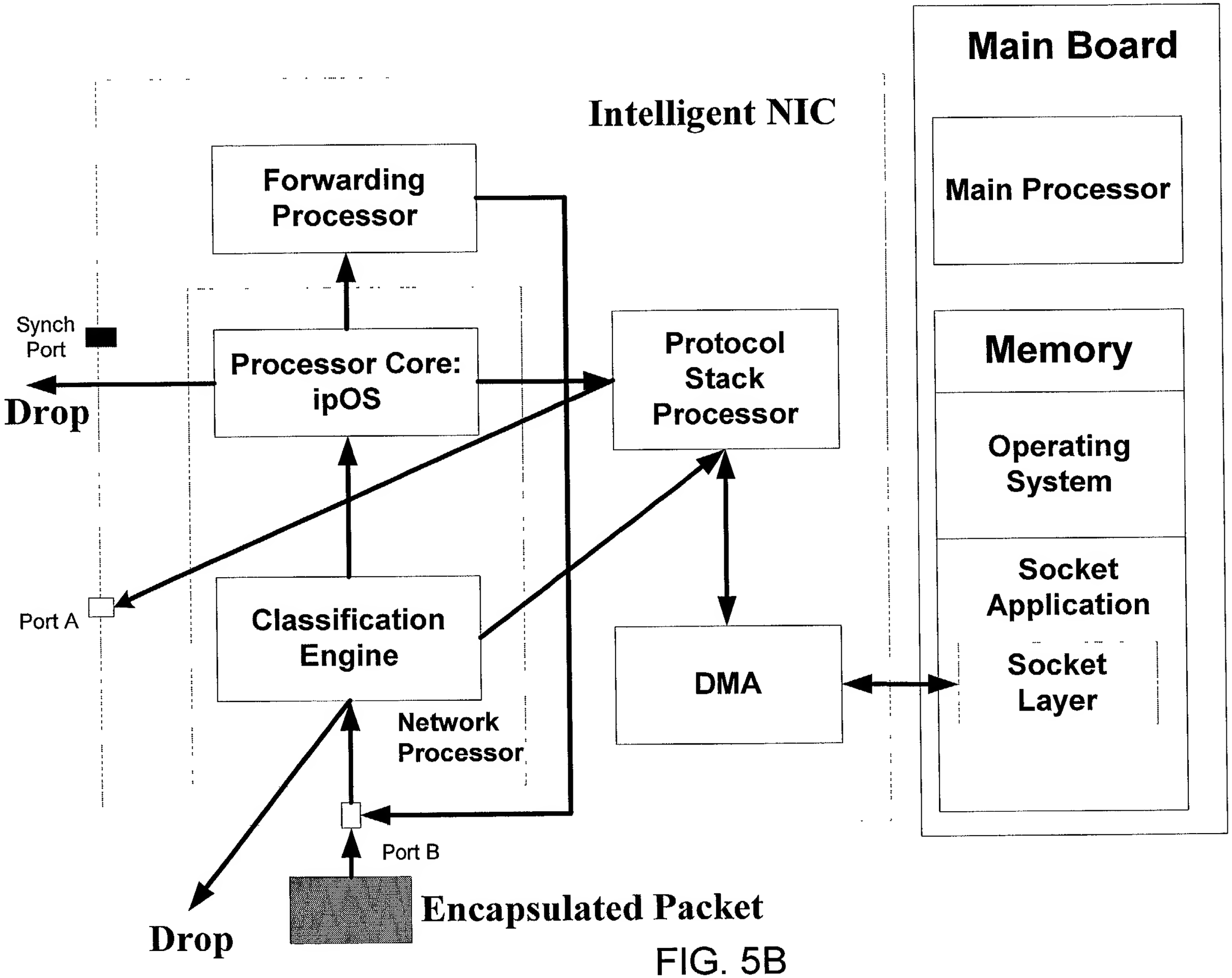

FIG. 5B

29820.8
11 of 28

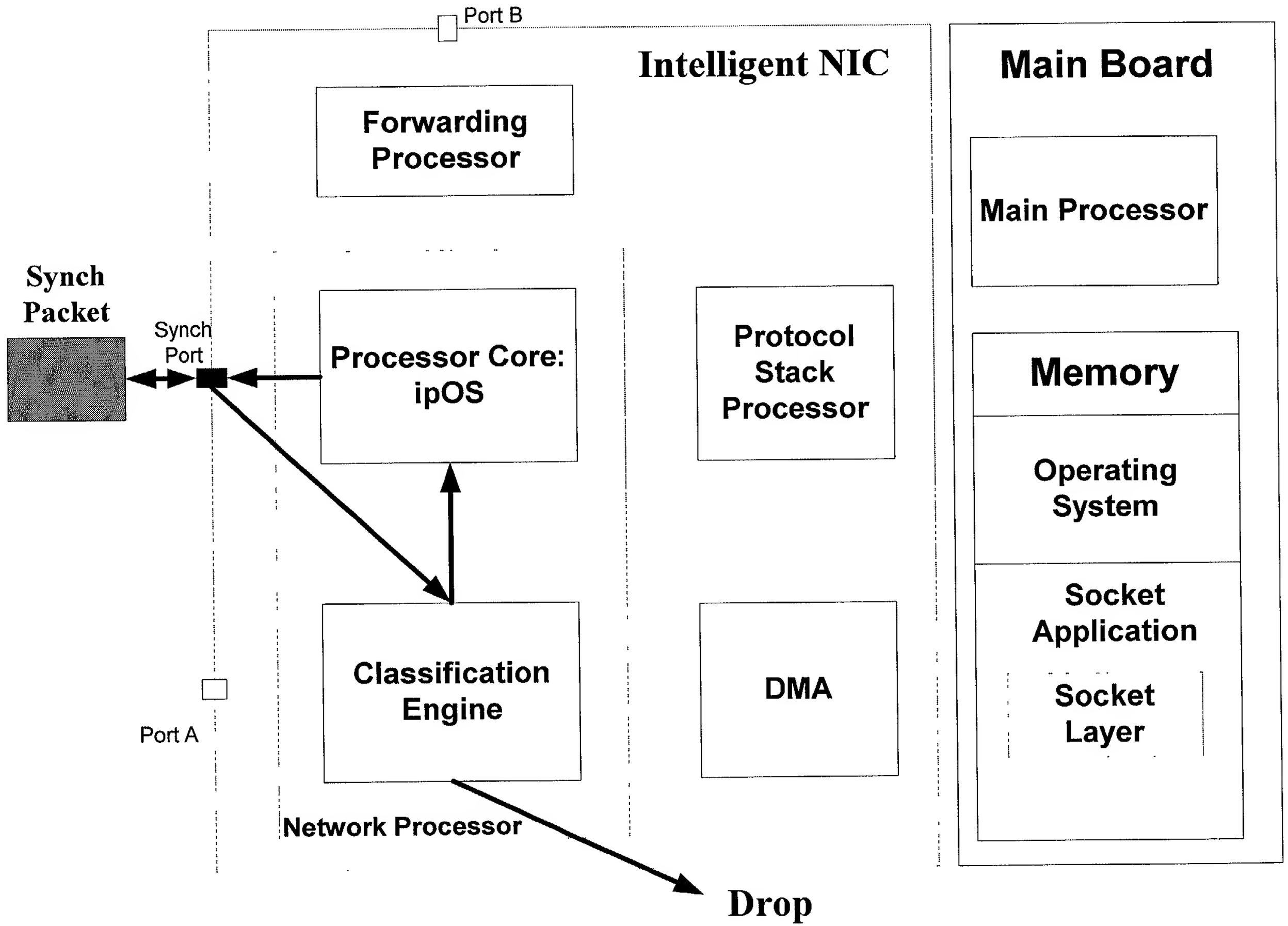
Port B
Intelligent NIC
Forwarding Processor
Synch Packet
Synch Port
Processor Core: ipOS
Protocol Stack Processor
Classification Engine
DMA
Port A
Network Processor
Drop
Main Board
Main Processor
Memory
Operating System
Socket Application
Socket Layer

FIG. 5C

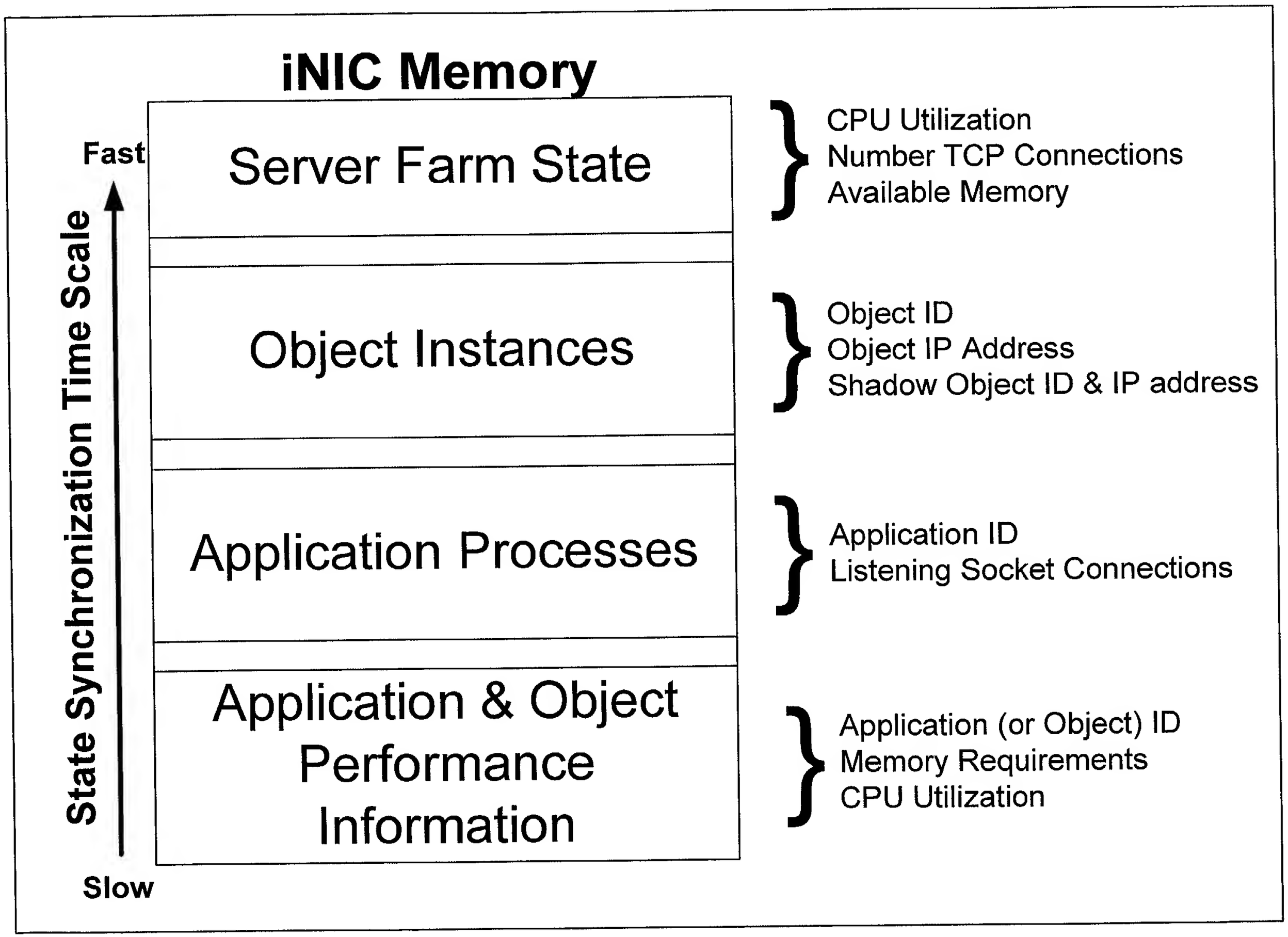
iNIC Memory
Fast
State Synchronization Time Scale
Slow
Server Farm State
Object Instances
Application Processes
Application & Object Performance Information
CPU Utilization
Number TCP Connections
Available Memory
Object ID
Object IP Address
Shadow Object ID & IP address
Application ID
Listening Socket Connections
Application (or Object) ID
Memory Requirements
CPU Utilization

FIG. 6

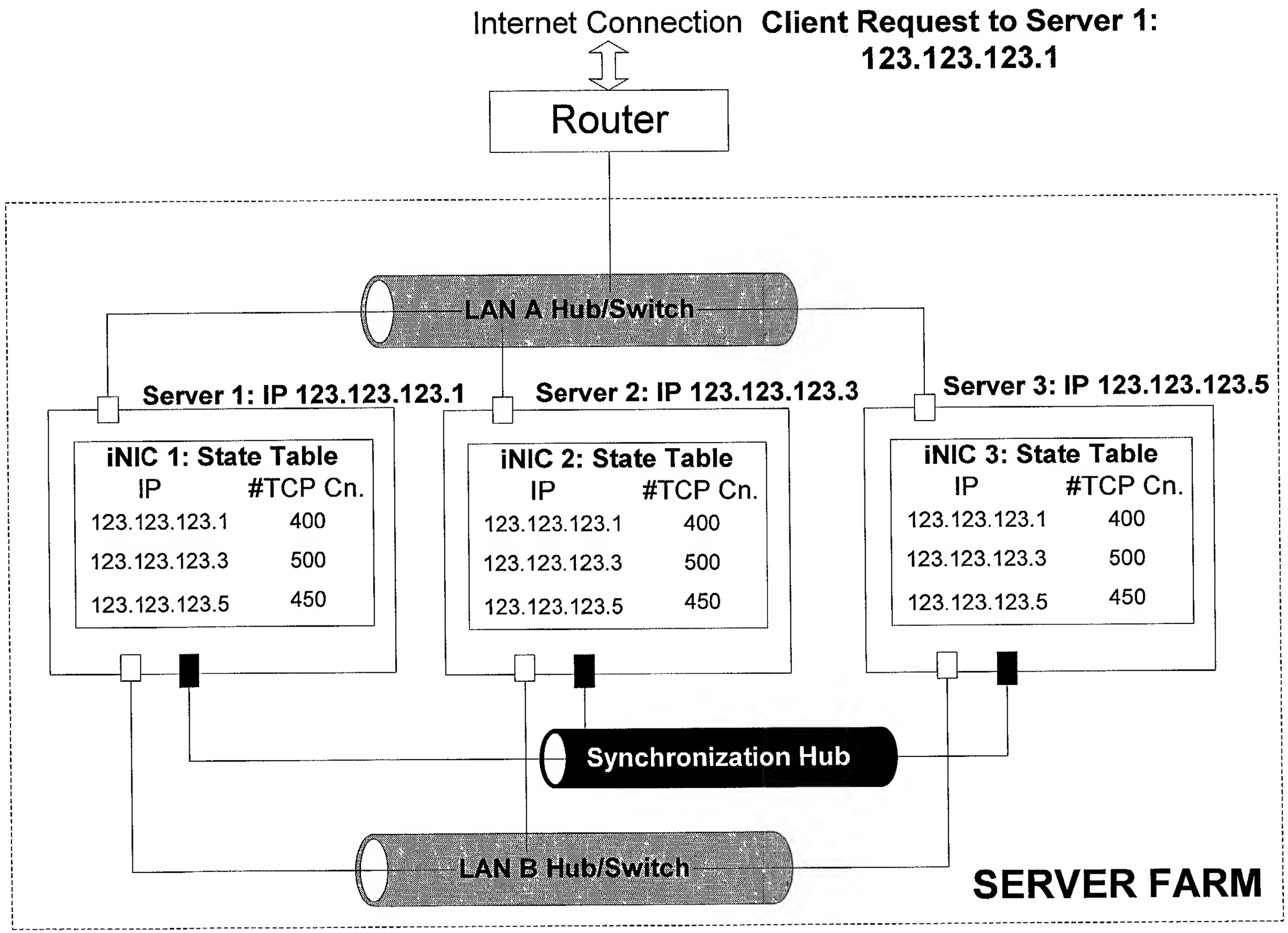
Internet Connection
Client Request to Server 1:
123.123.123.1
Router
LAN A Hub/Switch
Server 1: IP 123.123.123.1
Server 2: IP 123.123.123.3
Server 3: IP 123.123.123.5
iNIC 1: State Table
IP #TCP Cn.
123.123.123.1 400
123.123.123.3 500
123.123.123.5 450
iNIC 2: State Table
IP #TCP Cn.
123.123.123.1 400
123.123.123.3 500
123.123.123.5 450
iNIC 3: State Table
IP #TCP Cn.
123.123.123.1 400
123.123.123.3 500
123.123.123.5 450
Synchronization Hub
LAN B Hub/Switch
SERVER FARM

FIG. 7

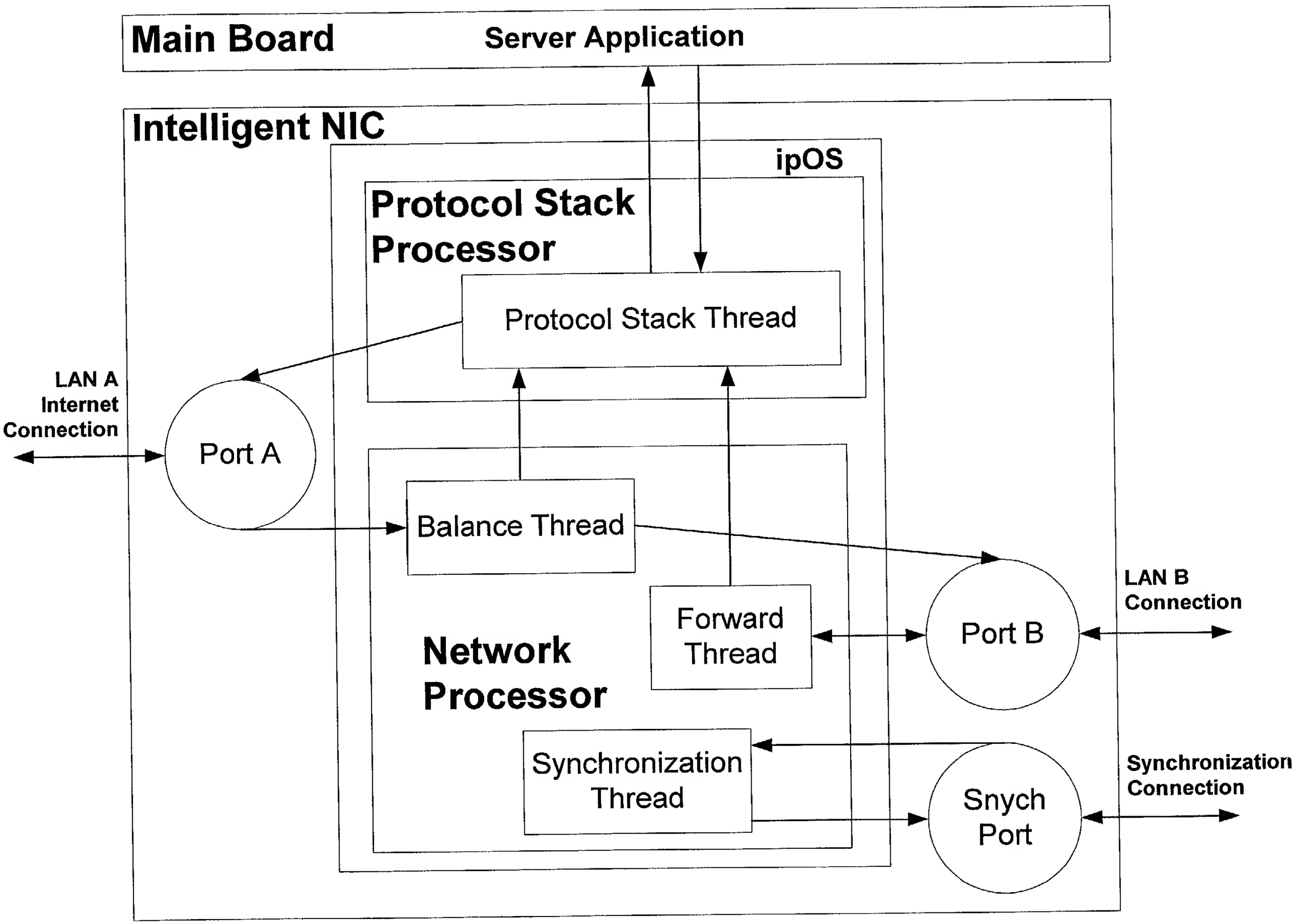
Main Board
Server Application
Intelligent NIC
ipOS
Protocol Stack Processor
Protocol Stack Thread
LAN A Internet Connection
Port A
Balance Thread
Network Processor
Forward Thread
Port B
LAN B Connection
Synchronization Thread
Snych Port
Synchronization Connection

FIG. 8

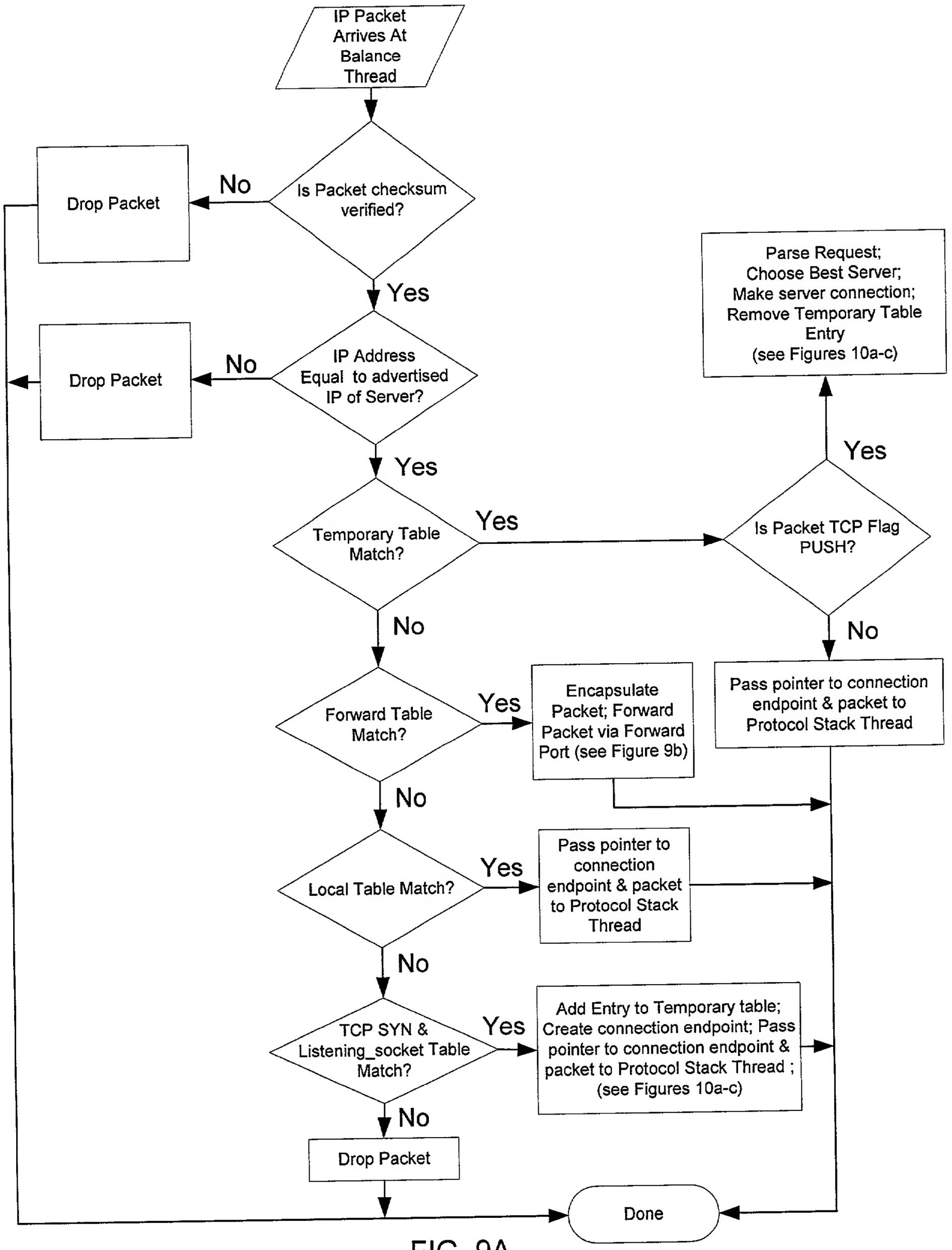
IP Packet Arrives At Balance Thread
Is Packet checksum verified?
No
Drop Packet
Yes
IP Address Equal to advertised IP of Server?
No
Drop Packet
Yes
Temporary Table Match?
Yes
Is Packet TCP Flag PUSH?
Yes
Parse Request; Choose Best Server; Make server connection; Remove Temporary Table Entry (see Figures 10a-c)
No
Pass pointer to connection endpoint & packet to Protocol Stack Thread
No
Forward Table Match?
Yes
Encapsulate Packet; Forward Packet via Forward Port (see Figure 9b)
No
Local Table Match?
Yes
Pass pointer to connection endpoint & packet to Protocol Stack Thread
No
TCP SYN & Listening_socket Table Match?
Yes
Add Entry to Temporary table; Create connection endpoint; Pass pointer to connection endpoint & packet to Protocol Stack Thread ; (see Figures 10a-c)
No
Drop Packet
Done

FIG. 9A

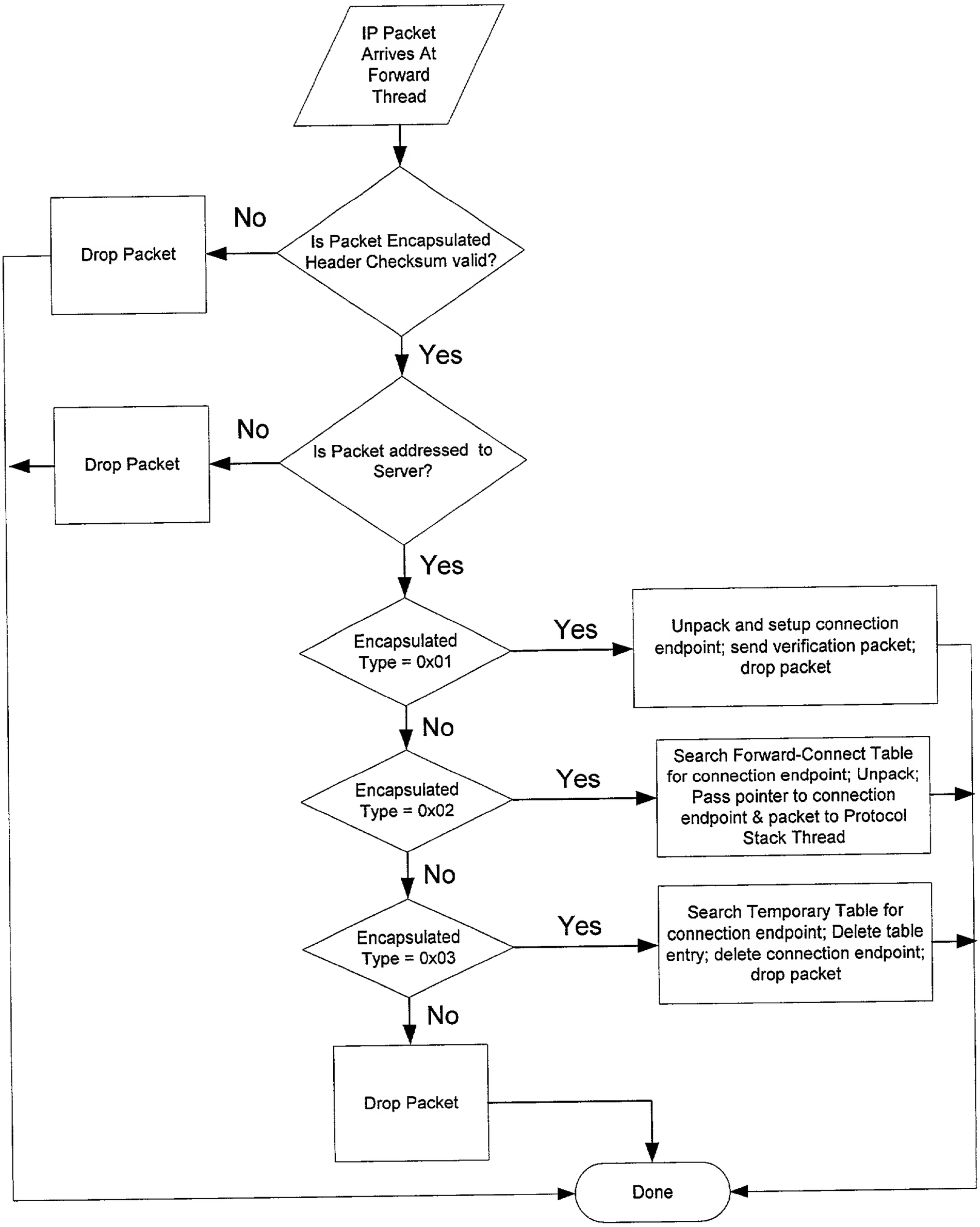
IP Packet Arrives At Forward Thread
Is Packet Encapsulated Header Checksum valid?
No
Drop Packet
Yes
Is Packet addressed to Server?
No
Drop Packet
Yes
Encapsulated Type = 0x01
Yes
Unpack and setup connection endpoint; send verification packet; drop packet
No
Encapsulated Type = 0x02
Yes
Search Forward-Connect Table for connection endpoint; Unpack; Pass pointer to connection endpoint & packet to Protocol Stack Thread
No
Encapsulated Type = 0x03
Yes
Search Temporary Table for connection endpoint; Delete table entry; delete connection endpoint; drop packet
No
Drop Packet
Done

FIG. 9B

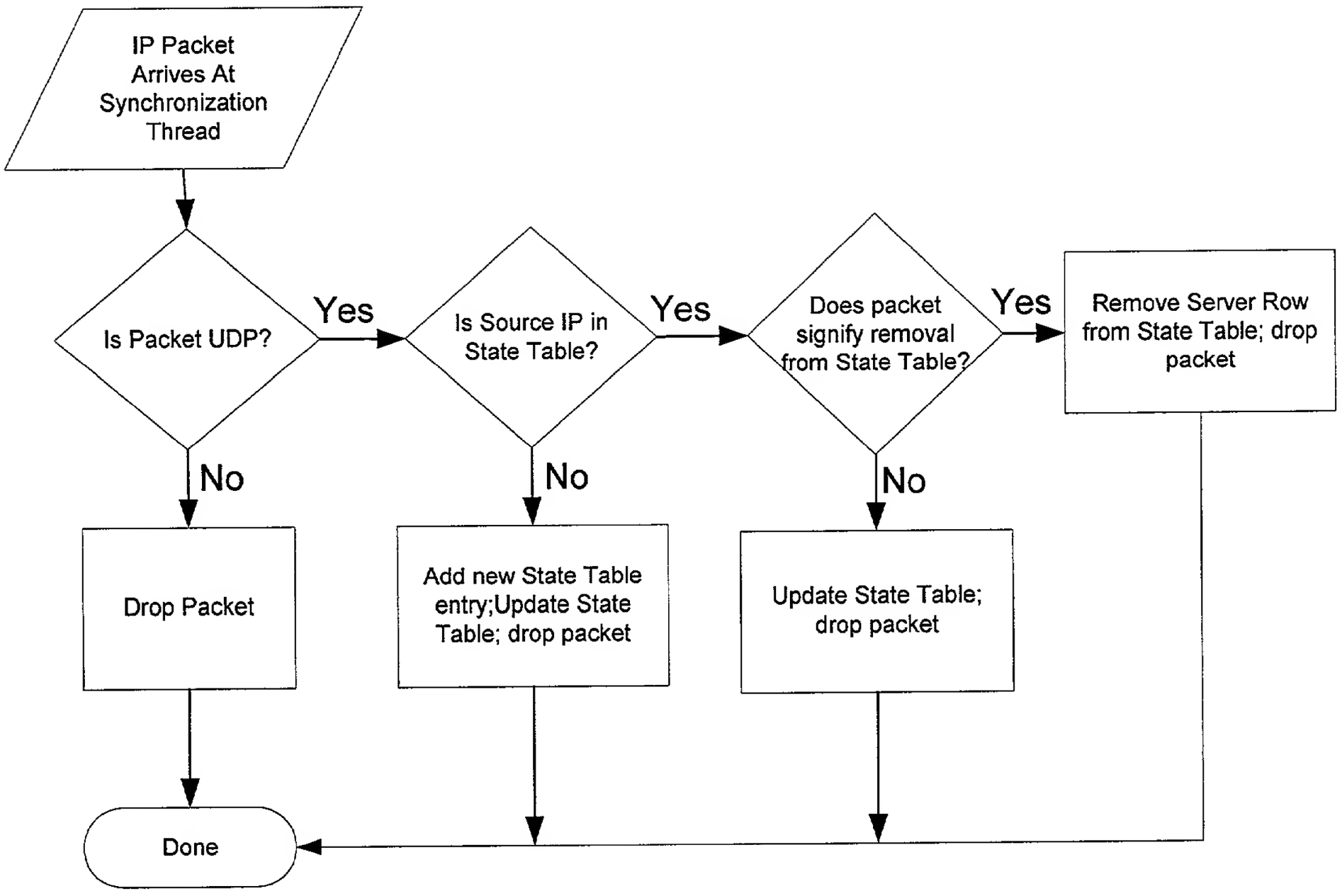
IP Packet Arrives At Synchronization Thread
Is Packet UDP?
Yes
Is Source IP in State Table?
Yes
Does packet signify removal from State Table?
Yes
Remove Server Row from State Table; drop packet
No
Drop Packet
No
Add new State Table entry;Update State Table; drop packet
No
Update State Table; drop packet
Done

FIG. 9C

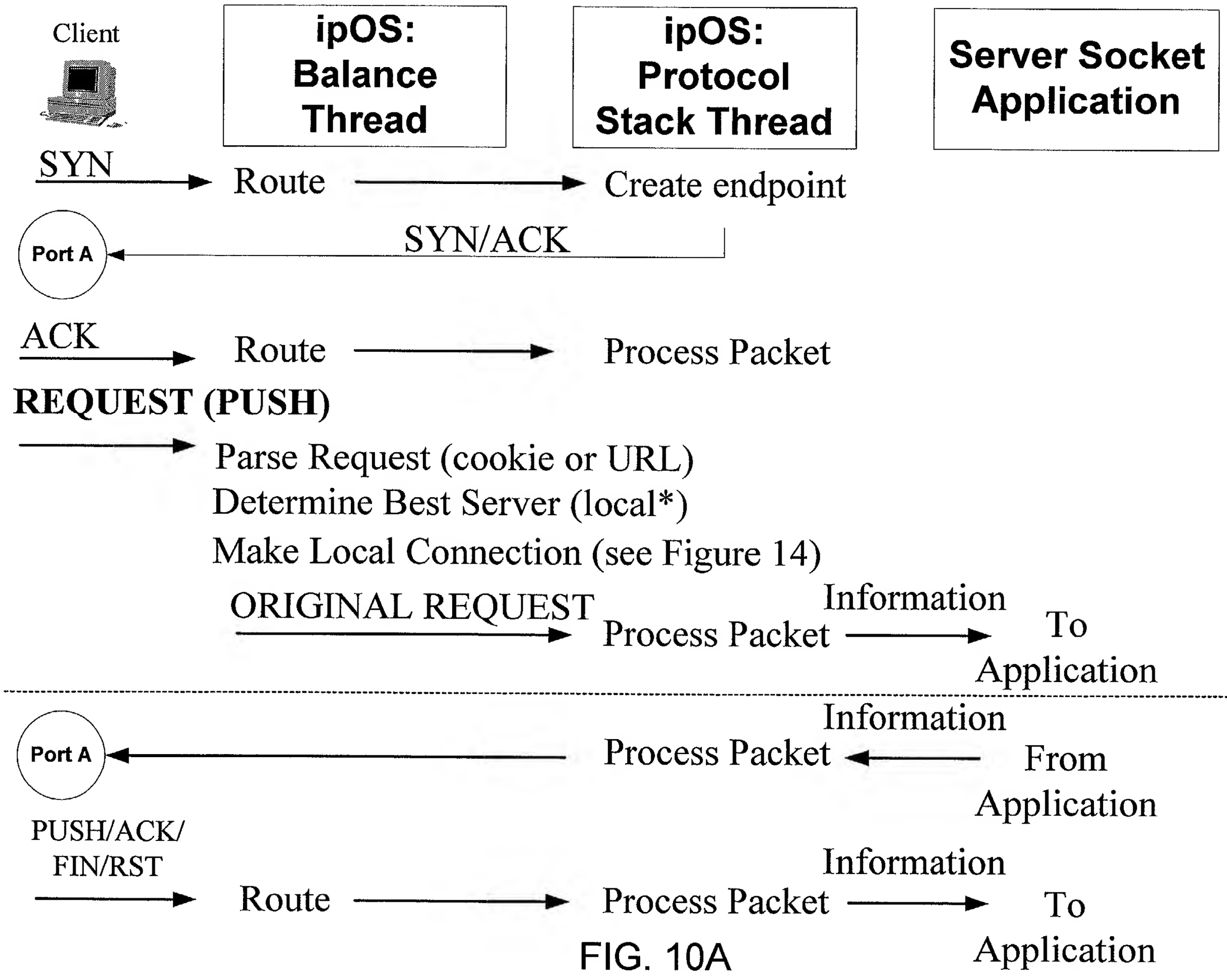
Client
ipOS: Balance Thread
ipOS: Protocol Stack Thread
Server Socket Application
SYN
Route
Create endpoint
Port A
SYN/ACK
ACK
Route
Process Packet
REQUEST (PUSH)
Parse Request (cookie or URL)
Determine Best Server (local*)
Make Local Connection (see Figure 14)
ORIGINAL REQUEST
Process Packet
Information To Application
Port A
Process Packet
Information From Application
PUSH/ACK/ FIN/RST
Route
Process Packet
Information To Application

FIG. 10A

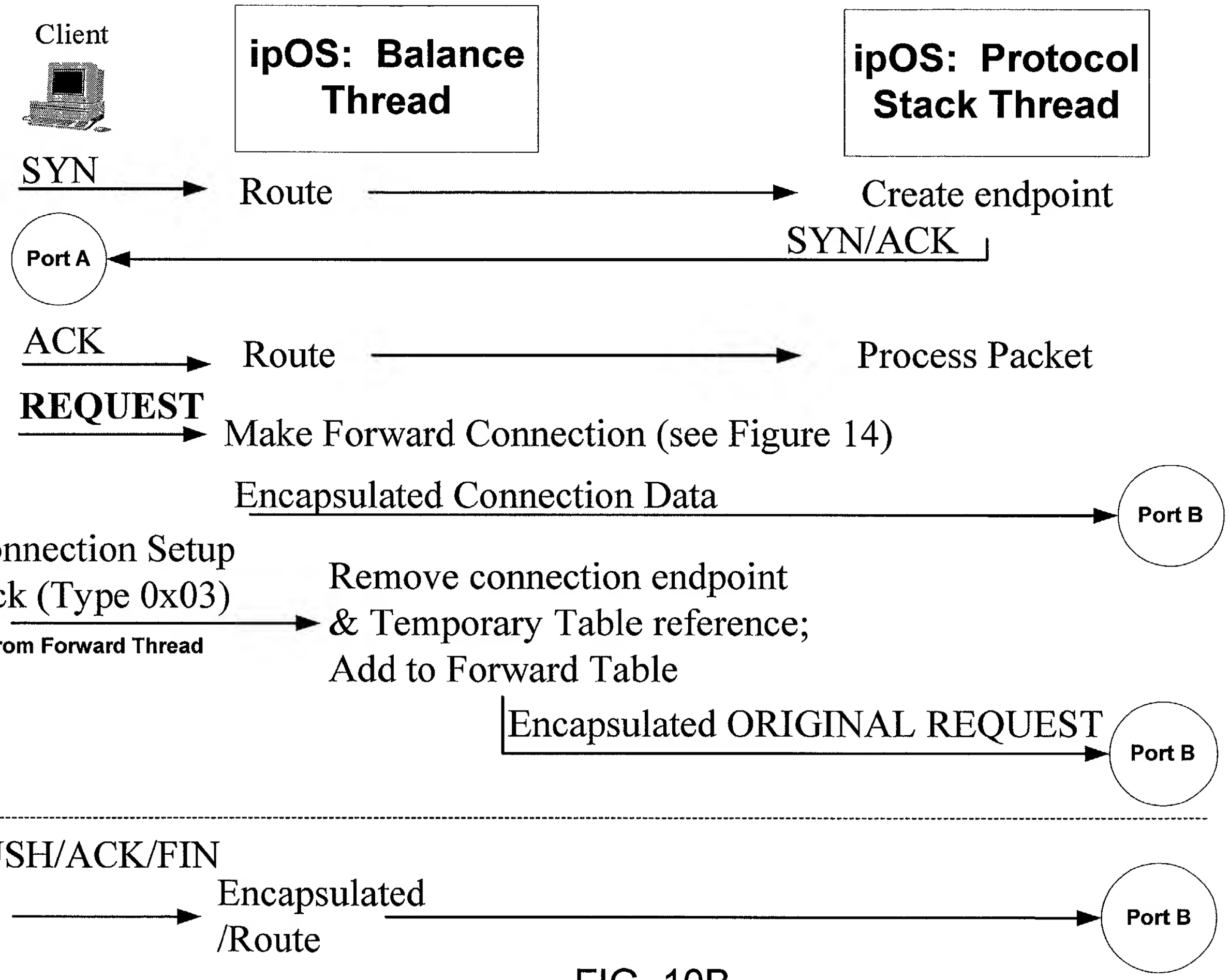
Client
ipOS: Balance Thread
ipOS: Protocol Stack Thread
SYN
Route
Create endpoint
SYN/ACK
Port A
ACK
Route
Process Packet
REQUEST
Make Forward Connection (see Figure 14)
Encapsulated Connection Data
Port B
Connection Setup Ack (Type 0x03)
**from Forward Thread
Remove connection endpoint & Temporary Table reference; Add to Forward Table
Encapsulated ORIGINAL REQUEST
Port B
PUSH/ACK/FIN
Encapsulated /Route
Port B

FIG. 10B

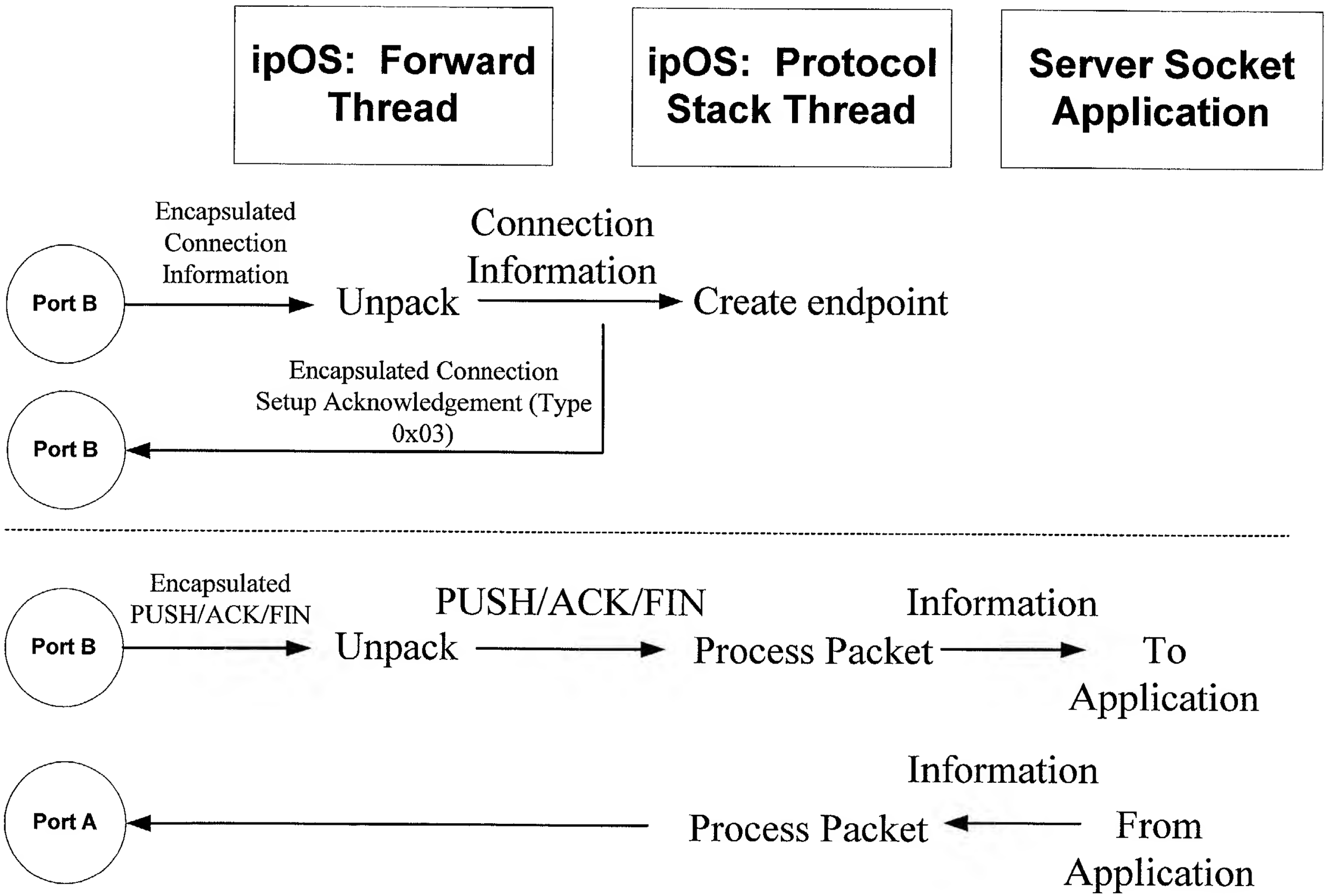
ipOS: Forward Thread
ipOS: Protocol Stack Thread
Server Socket Application
Encapsulated Connection Information
Port B
Unpack
Connection Information
Create endpoint
Encapsulated Connection Setup Acknowledgement (Type 0x03)
Port B
Encapsulated PUSH/ACK/FIN
Port B
Unpack
PUSH/ACK/FIN
Process Packet
Information To Application
Port A
Process Packet
Information From Application

FIG. 10C

Ethernet Encapsulation Header

MAC Destination Address	MAC Source Address	Type 0x007
6	6	2

FIG. 11A
(Prior Art)

ipOS Encapsulation Header

Source IP	Source Port	Dest. IP	Dest. Port	Type	Protocol	Checksum
4	2	4	2	1	1	2

FIG. 11B

ipOS Connection Information (UDP)

Server IP	Server Port
4	2

FIG. 11C

ipOS Connection Information (TCP)

Server IP	Server Port	TCP Control Block Information
4	2	140

FIG. 11D

ipOS TCP Connection Packet (Type=0x01; Protocol=0x01)

Ethernet Encap. Type =0x007	ipOS Encap. Header	TCP ipOS Connection Information
14	16	146

FIG. 11E

ipOS UDP Connection Packet (Type=0x01; Protocol=0x02)

Ethernet Encap. Type =0x007	ipOS Encap. Header	UDP ipOS Connection Information
14	16	6

FIG. 11F

ipOS TCP Packet (Type=0x02; Protocol=0x01)

Ethernet Encap. Type =0x007	ipOS Encap. Header	IP/TCP Packet
14	16	40 + Data

FIG. 11G

ipOS UDP Packet (Type=0x02; Protocol=0x02)

Ethernet Encap. Type =0x007	ipOS Encap. Header	IP/UDP Packet
14	16	28 + Data

FIG. 11H

ipOS Endpoint Migration Acknowledgement Packet (Type=0x03)

Ethernet Encap. Type =0x007	ipOS Encap. Header
14	16

FIG. 11I

Express Mail Label No. EV 339 920 945 US

Forward Table

Key	Field	Description
Yes	Source IP Address	IP address of Client
Yes	Source TCP Port	TCP Port of Client
No	Destination IP Address	IP Address to Forward
No	Destination TCP Port	TCP Port to Forward

Local/Forward-Connect/Temporary Table

KEY	Field	Description
Yes	Source IP Address	Client IP address
Yes	Source Port	Client TCP Port
Yes	Destination IP Address	Endpoint IP Address
Yes	Destination Port	Endpoint TCP Port
No	Endpoint Reference	Reference to Connection Endpoint

Server State Table

Key	Field	Description
Yes	Server IP Address	Server
No	Number TCP Connections	TCP Established Connections
No	CPU utilization	Main board CPU utilization
No	Available memory	Unused memory on Main Board
No	Available Bandwidth	Unused Bandwidth Capacity

Listening Sockets Table

Key	Field	Description
Yes	Server IP Address	Server
Yes	TCP Port	Advertised TCP Port
No	Process	Application process advertising IP/Port

Application Information Table

Key	Field	Description
Yes	Process ID	Application identification
No	Process memory requirements	Memory required to run application
No	Process CPU Utilization	Measure of application CPU utilization

URL Map Table

Key	Field	Description
Yes	URL	Universal Resource Locator
Yes	Server IP Address	IP address of associated server

Cookie Map Table

Key	Field	Description
Yes	Cookie ID	Cookie Identification tag
No	Server IP Address	IP address of associated server

FIG. 12

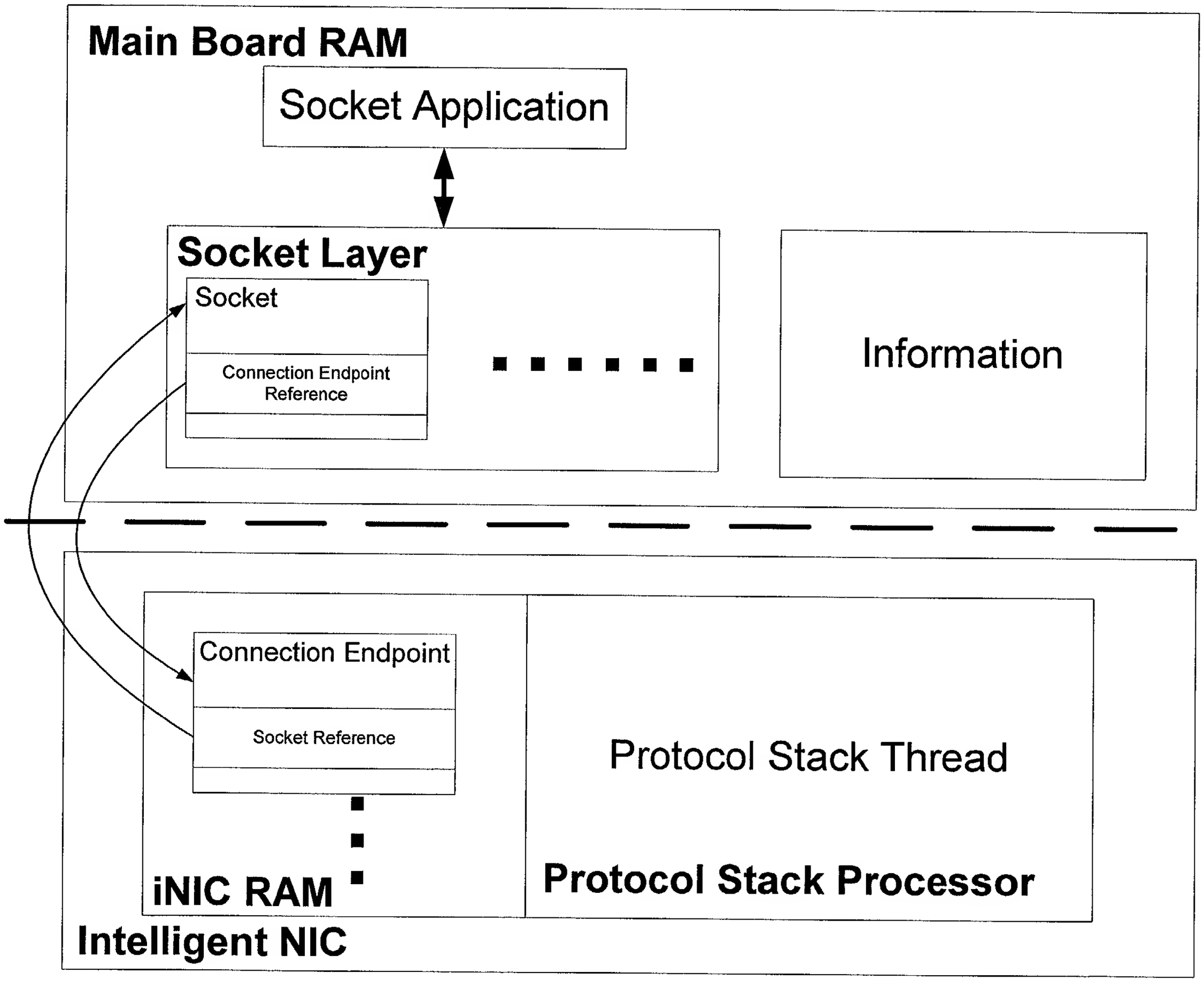
Main Board RAM
Socket Application
Socket Layer
Socket
Connection Endpoint Reference
Information
Connection Endpoint
Socket Reference
Protocol Stack Thread
iNIC RAM
Protocol Stack Processor
Intelligent NIC

FIG. 13

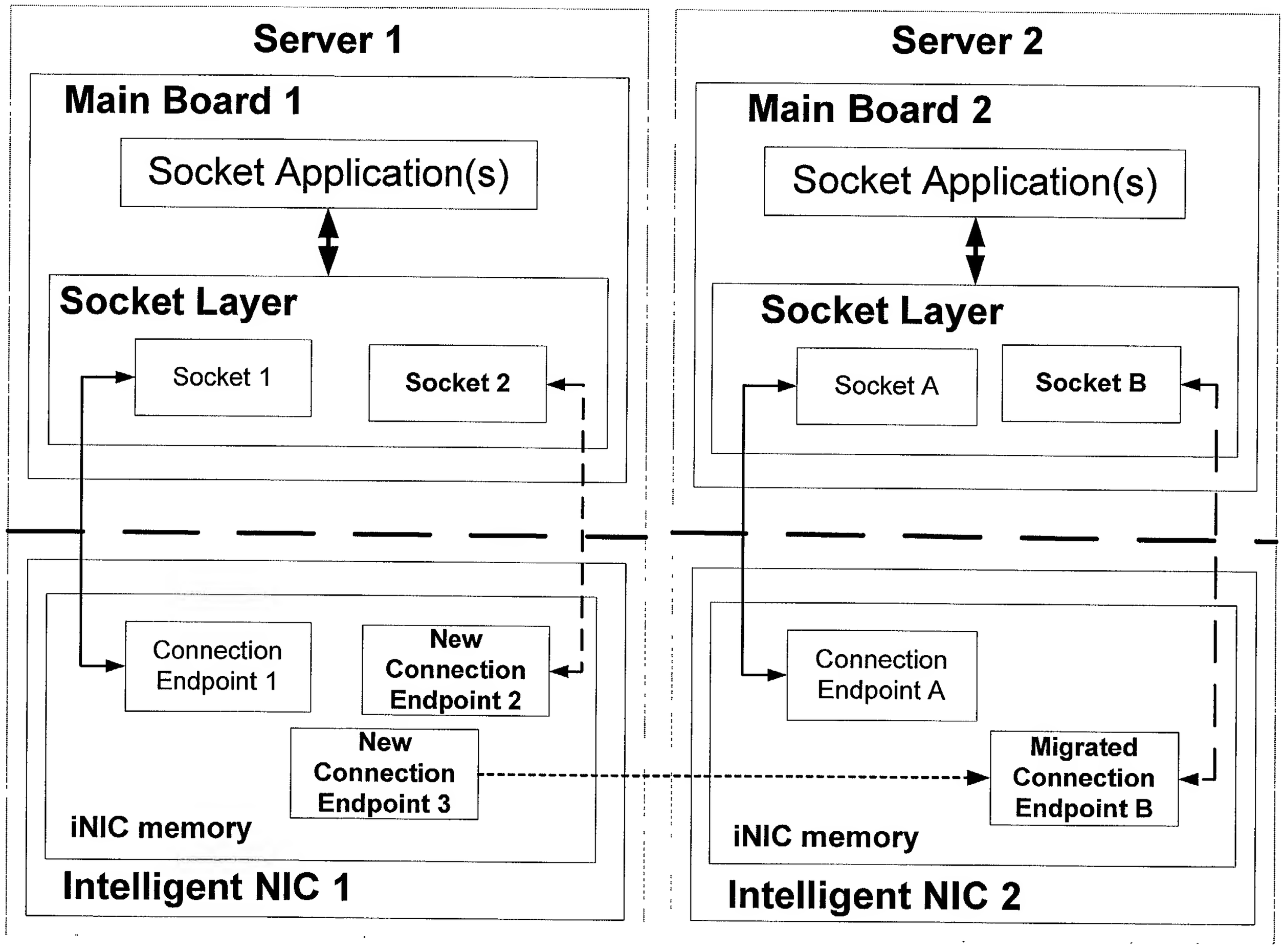
Server 1
Main Board 1
Socket Application(s)
Socket Layer
Socket 1
Socket 2
Server 2
Main Board 2
Socket Application(s)
Socket Layer
Socket A
Socket B
Connection Endpoint 1
New Connection Endpoint 2
New Connection Endpoint 3
iNIC memory
Intelligent NIC 1
Connection Endpoint A
Migrated Connection Endpoint B
iNIC memory
Intelligent NIC 2

FIG. 14

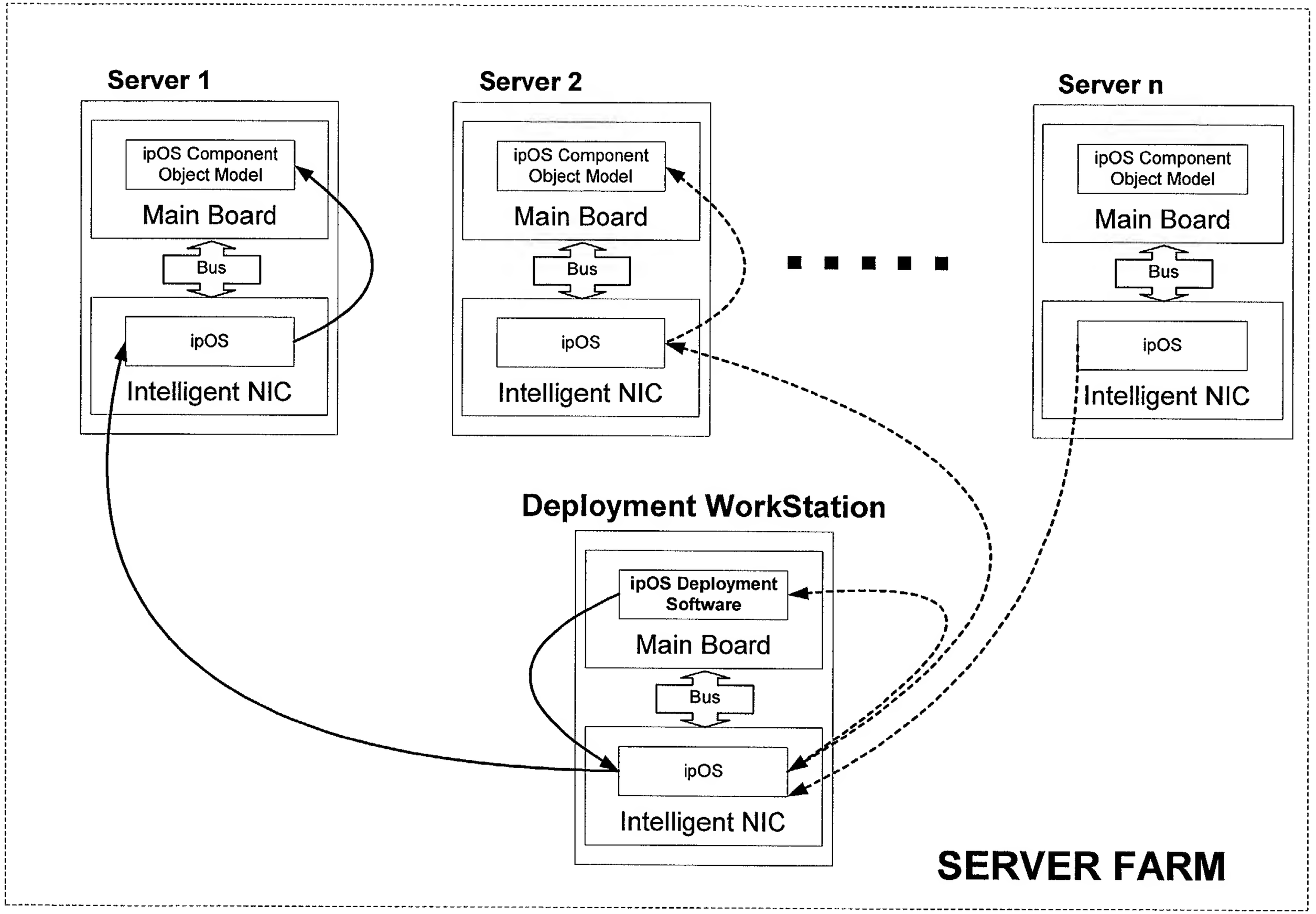
Server 1
ipOS Component Object Model
Main Board
Bus
ipOS
Intelligent NIC
Server 2
ipOS Component Object Model
Main Board
Bus
ipOS
Intelligent NIC
Server n
ipOS Component Object Model
Main Board
Bus
ipOS
Intelligent NIC
Deployment WorkStation
ipOS Deployment Software
Main Board
Bus
ipOS
Intelligent NIC
SERVER FARM

FIG. 15

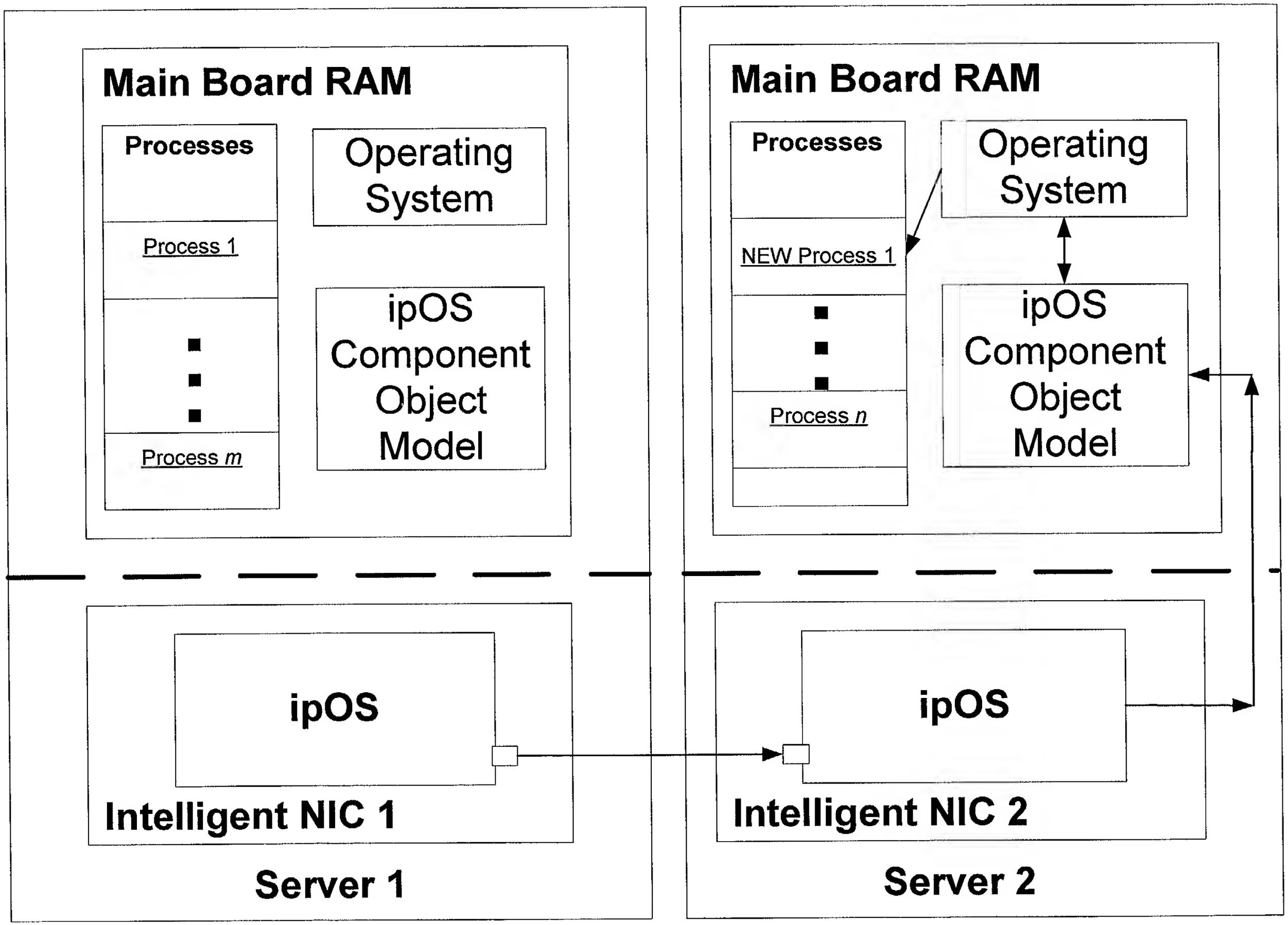
Main Board RAM
Processes
Process 1
Process m
Operating System
ipOS Component Object Model
ipOS
Intelligent NIC 1
Server 1
Main Board RAM
Processes
NEW Process 1
Process n
Operating System
ipOS Component Object Model
ipOS
Intelligent NIC 2
Server 2

FIG. 16

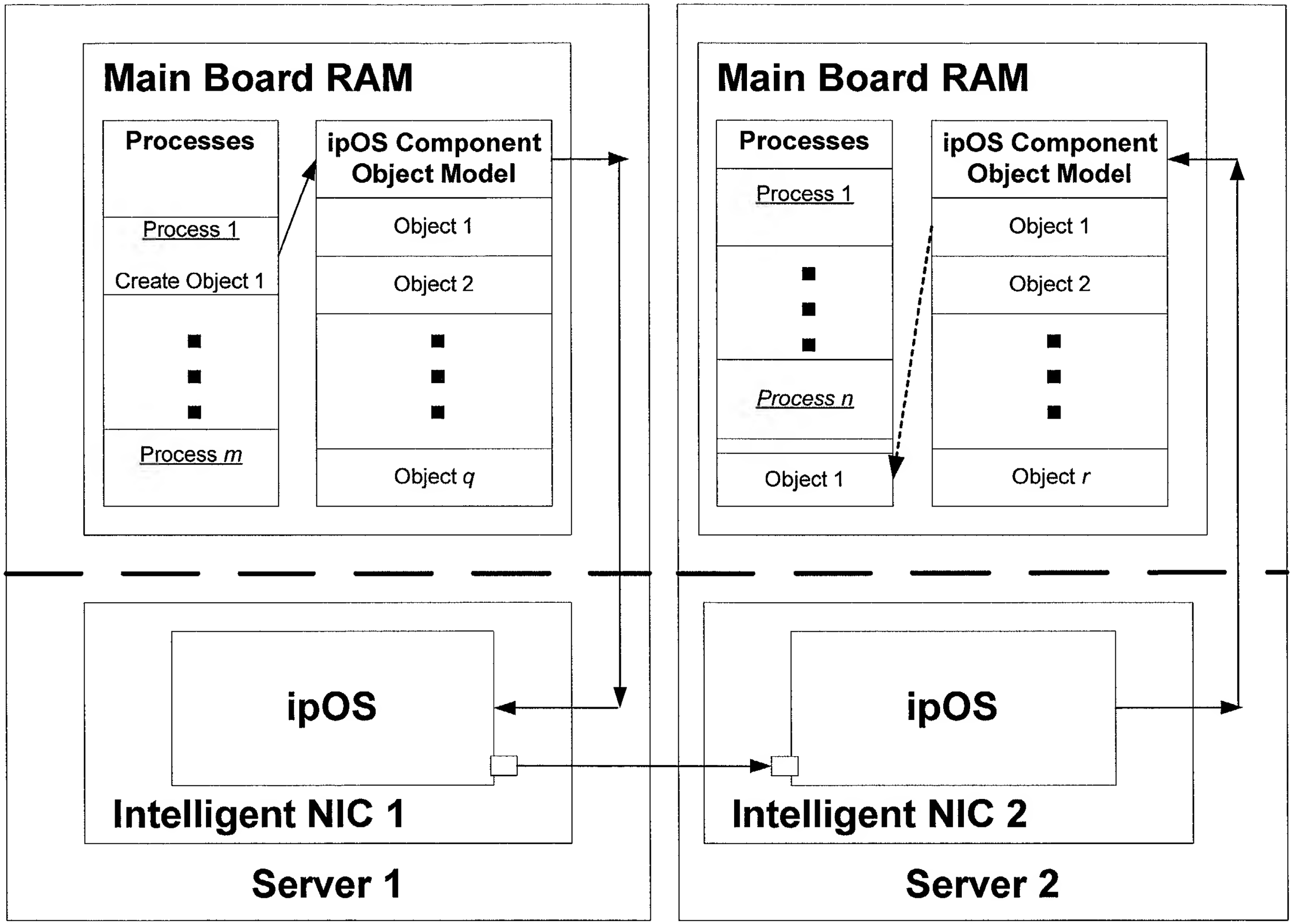
Main Board RAM
Processes
Process 1
Create Object 1
Process m
ipOS Component Object Model
Object 1
Object 2
Object q
Main Board RAM
Processes
Process 1
Process n
Object 1
ipOS Component Object Model
Object 1
Object 2
Object r
ipOS
Intelligent NIC 1
Server 1
ipOS
Intelligent NIC 2
Server 2

FIG. 17